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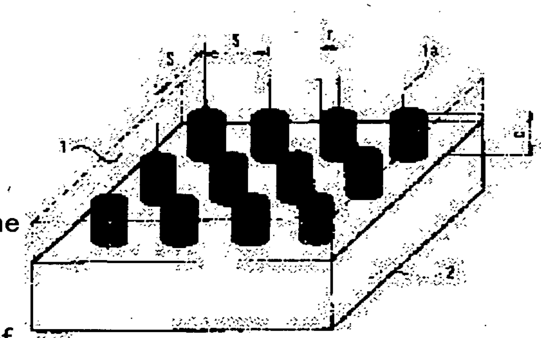
(54) OPTICAL MEMBER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide the reflection preventive effect with small influence of the polarized light at an arbitrary wavelength by forming an optical thin film having periodically arranged recessed parts on a substrate, or periodically forming projecting parts formed of an optical thin film material.

SOLUTION: In an optical member, an approximately cylindrical projecting part 1a of (r) in radius and (d) in height formed of an optical thin film material for the wavelength range of 120-180 nm is periodically formed on a substrate 1 with the periodical length S. The substrate 2 to be used, is formed of magnesium fluoride MgF_2 and fluorite CaF_2 capable of transmitting the light in the wavelength range of 120-180 nm. The material of the optical thin film capable of being used in the wavelength range of 120-180 nm is preferably the same as that of the substrate, or the material whose refractive index is smaller than that of the substrate, and includes MgF_2, CaF_2, LiF, Na_3AlF_6, $Na_5Al_3F_{11}$, AlF_3 and one or more components selected from the group of the mixture or the compound thereof. The similar reflection preventive effect to that of the optical thin film having the desired refractive index formed on the substrate, is obtained thereby.



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CLAIMS

[Claim(s)]

[Claim 1] an acid-resisting layer which a crevice becomes from a 120nm - 200nm optical thin film material for wavelength fields prepared periodically -- or an optical member which has on a substrate an acid-resisting layer in which it comes to form heights with an optical thin film material for 120nm - 200nm wavelength fields periodically.

[Claim 2] An optical member according to claim 1 characterized by said cycle length being 1/10 or less [of operating wavelength].

[Claim 3] Claim 1 characterized by said 120nm - 200nm optical thin film materials for wavelength fields being one or more components chosen from a group of MgF2, CaF2, LiF, Na3AlF6, Na5aluminum3F14, AlF(s)3 and such quality of mixture, or a compound, and an optical member given in two.

[Claim 4] An optical member according to claim 1 to 3 characterized by that an effectual refractive index of said acid-resisting layer fills relation between n=(n1) 1/2 to a refractive index of a substrate, or optical thickness of said layer filling relation of n-d=lambda 0/4 to operating wavelength. However, for a refractive index of a substrate, and d, thickness of said acid-resisting layer and lambda 0 are [a refractive index of an acid-resisting layer in which n includes space (medium) of each crevice, or space between each heights (medium), and n1] operating wavelength.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to an antireflection film effective in the light of 120nm - 200nm wavelength fields, such as ArF laser and F2 laser.
[0002]
[Description of the Prior Art] In optical system, in order to reduce quantity of light loss, a flare ghost, etc. by surface reflection of optical elements, such as a lens, it is necessary to form an antireflection film. As a configuration of such an antireflection film, the configuration which carries out the laminating of for example, a high refractive-index layer and the low refractive-index layer by turns is mentioned. Moreover, from such light, although there are an ArF excimer laser (lambda= 193.4nm), F2 laser (lambda= 157nm), etc. as the light source used in a 120nm - 200nm wavelength field, in order to be an effective antireflection film, low absorption and laser-proof [quantity] nature are required. However, in operating wavelength lambda0 <=200nm, usable high refractive-index material and low refractive-index material decrease. Especially, in lambda0 <=180nm, since usable high refractive-index material without absorption now does not exist, the multilayer antireflection film which does the effective acid-resisting effect so cannot be obtained.
[0003] On the other hand, as a method of acquiring the desired acid-resisting effect by monolayer, as shown in drawing 5 from the former, the optical member which has the acid-resisting effect is known by etching removing periodically by cycle length smaller than operating wavelength, and forming the wedge-like thin film 3 on the optical substrate 1.
[0004]
[Problem(s) to be Solved by the Invention] However, by the pattern of the shape of a wedge as shown in drawing 5 , the polarization direction (the direction of A in drawing) which does the acid-resisting effect so according to the polarization direction of the light which carries out incidence, and the polarization direction (the direction of B in drawing) without the effect of acid resisting will exist. Namely, when vibration of the electric field of incident light has a component in the direction of a ridgeline of a wedge, as for the component, the acid-resisting effect is not acquired. Moreover, it becomes difficult to form the configuration of a wedge as operating wavelength will short-wavelength-ize since the effect of acid resisting is small if the cycle length of a wedge is not 1/10 or less [of operating wavelength]. As an actual problem, by 1 micrometer or less, since the cycle length of a wedge is set to 0.1 micrometers or less, the operating wavelength lambda cannot form the configuration of a wedge with a sufficient precision (it forms by etching).
[0005] Then, this invention is made in view of such a trouble, and it is a thing and is 0<=200nm of operating wavelength 120 nm<=lambda, and it does not depend in the polarization direction of incident light, but it aims at offering the optical member which does the acid-resisting effect so.
[0006]
It is means] in order to solve [technical problem. this invention -- the first -- "-- a crevice -- periodic -- preparing -- having had -- 120 -- nm - 200 -- nm -- wavelength -- a field -- ** -- optics -- a thin film material -- from -- becoming -- acid resisting -- a layer -- or -- 120 -- nm - 200 -- nm -- wavelength -- a field -- ** -- optics -- a thin film material -- heights -- periodic -- forming -- having -- becoming -- acid resisting -- a layer -- a substrate -- a top -- having -- optics -- a member (claim 1) -- " --

providing .
[0007] Moreover, this invention provides the second with "the optical member (claim 2) according to claim 1 characterized by said cycle length being 1/10 or less [of operating wavelength]." Moreover, this invention provides the third with "claim 1 characterized by said 120nm - 200nm optical thin film materials for wavelength fields being one or more components chosen from the group of MgF2, CaF2, LiF, Na3AlF6, Na5aluminum3F14, AlF(s)3 and such quality of mixture, or a compound and an optical member (claim 3) given in two."
[0008] moreover, this invention -- the fourth -- "-- the optical member according to claim 1 to 3 characterized by that the effectual refractive index of said acid-resisting layer fills the relation between n=(n1) 1/2 to the refractive index of a substrate, or the optical thickness of said layer filling the relation of n-d=lambda 0/4 to operating wavelength. however -- n -- each -- a crevice -- space (medium) -- or -- each -- heights -- between -- space (medium) -- containing -- acid resisting -- a layer -- a refractive index -- n -- one -- a substrate -- a refractive index -- d -- said -- acid resisting -- a layer -- thickness -- lambda -- zero -- use -- wavelength (claim 4) -- " -- providing .
[0009]
[Embodiment of the Invention] Below, it explains, referring to a drawing about the optical member as an operation gestalt of this invention. Drawing 1 is the outline perspective diagram of the optical member of the 1st operation gestalt concerning this invention. Drawing 2 is the outline perspective diagram of the optical member of the 2nd operation gestalt concerning this invention.
[0010] As for the optical member of the 1st operation gestalt, approximately cylindrical heights 1of radius [which consists of an optical thin film material for 120nm - 180nm wavelength fields on a substrate 1] r, and height d a is periodically formed by cycle length S. the -- two -- operation -- a gestalt -- optics -- a member -- a substrate -- two -- a top -- a radius -- r -- height -- d -- being approximately cylindrical -- a crevice -- one -- a -- ' -- cycle length -- S -- periodic -- preparing -- having had -- 120 -- nm - 180 -- nm -- wavelength -- a field -- ** -- optics -- a thin film -- one -- ' -- forming -- having -- **** .
[0011] As a substrate 2, the magnesium fluoride (MgF2) and fluorite (CaF2) which penetrate the light of a 120nm - 180nm wavelength field are used. As an optical thin film usable in a 120nm - 180nm wavelength field, the same material as a substrate or a material smaller than the refractive index of a substrate is desirable, and one or more components chosen from the group of MgF2, CaF2, LiF, Na3AlF6, Na5aluminum3F14, AlF(s)3 and such quality of mixture, or a compound are mentioned.
[0012] the layer 1 (it is called the layer which contains hereafter the heights formed on the substrate) which forms substrate 2 convex section 1a, and contains the heights 1a -- or the same acid-resisting effect as the case where the optical thin film (it does not exist now) which has a desired refractive index substantially is formed on a substrate can acquire by forming layer 1' which prepared crevice 1a' on the substrate. The cycle length S of heights 1a of the shape of a cylinder currently periodically formed on the substrate or crevice 1a' is S<=lambda 0/10, when operating wavelength is set to lambda 0. ... It is desirable that it is **.
[0013] It is because light cannot recognize irregularity if cycle length is made sufficiently smaller than operating wavelength. Moreover, by making the configuration of heights or a crevice into the shape of a cylinder, it cannot be based on the polarization condition of incident light, but can have the acid-resisting effect. Although a cone, a semi-sphere, the square pole, a rectangular-head drill, the triangle pole, a triangular pyramid, etc. are mentioned other than the shape of a cylinder and the same effect can be acquired also by these as a configuration of heights or a crevice, the shape of a cylinder is desirable at the point of being easy to manufacture.
[0014] The effectual refractive index n of layer 1' which prepared the layer 1 or crevice 1a' containing heights 1a formed on the substrate 2 is computable as follows with the ratio of the volume V1 of the space where material (thin film) exists in per unit (round term) volume, and the volume V2 of the space (medium, generally air) where material does not exist.
(1) The refractive index of the antireflection film of the optical member concerning the 1st operation

gestalt (drawing 1)
unit (round term) volume: -- volume [of a V=S2d cylinder (heights)]: -- refractive-index:n0 (= 1) of refractive-index:n2 medium (air) of the material which is volume:V2=V-V1=(S2-pir2) d in which V1= pir2d medium (air) exists, and constitutes a cylinder (heights)
Effectual refractive-index:n=(n2V1+n0V2)/V=[(n2pir2)+[n0 (S2-pir2)]]/S2=1+(n2-1) pir2/S2<n2 of the layer which contains the heights formed on the substrate when it carries out ... It is **.
[0015] This is substantially [as the optical member in which the optical thickness d and the thin film of refractive-index 1+(n2-1) pir2/S2 were formed on the substrate] the same.
(2) The refractive index of the antireflection film of the optical member concerning the 2nd operation gestalt (drawing 2)
unit (round term) volume: -- volume [of a V=S2d cylinder (crevice)] (medium section): -- volume:V2=V-V1=(S2-pir2) d in which V1= pir2d material (thin film) exists -- it is -- refractive-index:n0 (= 1) of refractive-index:n2 medium (air) of material (thin film)
Effectual refractive-index:n=(n0V1+n2V2)/V=[(n0pir2)+[n2 (S2-pir2)]]/S2=n2-(n2-1) pir2/S2<n2 of the layer which prepared the crevice when carried out ... It is **.
[0016] This is substantially [as the optical member in which the optical thickness d and the thin film of refractive-index n2-(n2-1) pir2/S2 were formed on the substrate] the same. As mentioned above, the effectual refractive index n of layer 1' which prepared the layer 1 or crevice 1a' containing heights 1a formed on the substrate By changing the volume of cylinder-like heights 1a or crevice 1a', in the range of the refractive index n2 of an optical thin film from the refractive index n0 (= 1) of air It can change into arbitration and a refractive index smaller than the refractive index n2 of the optical thin film material of the layer which prepared the optical thin film material of heights 1a or crevice 1a' can be obtained.
[0017] The acid-resisting effect will be acquired if the optical thin film of a refractive index smaller than the refractive index of a substrate is formed on a substrate. However, in order to acquire the effective acid-resisting effect, a reflection factor becomes the smallest on the target wavelength by forming an optical thin film on a substrate so that the refractive index n and the optical thickness nd of an optical thin film may fill a degree type.
n=n 11/2 (here, n1 is the refractive index of a substrate) ... ** n-d=lambda 0/4 (here, lambda 0 is operating wavelength) ... **, therefore the optical member concerning this invention a substrate -- two -- a top -- periodic -- forming -- having -- a cylinder -- ** -- heights -- one -- a -- containing -- a layer -- or -- a crevice -- one -- a -- ' -- having prepared -- a layer -- one -- ' -- being effectual -- a refractive index -- n -- optical -- thickness -- nd -- a formula -- ** -- ** -- filling -- as -- setting up -- things -- being effective -- acid resisting -- an effect -- having -- optics -- a member -- it can provide .
[0018] If the material or one kind of low refractive-index material used for a substrate is used for the optical member concerning this invention, it will become possible to acquire the acid-resisting effect. Furthermore, in the 1st and 2nd operation gestalt, although prepared periodically, heights and a crevice may be prepared at random, as long as the distance of the center to center of heights or a crevice fills or less lambda 0 / 10.
[0019]
[Example]
[Example 1] The magnesium fluoride (MgF2) of d= 31.4nm of thickness was first formed with the vacuum deposition method on the fluorite (CaF2) substrate. Next, the electron beam exposure system and the dry etching method were used on the magnesium fluoride (MgF2) which formed membranes, and a detailed pattern like drawing 2 as for which the cylinder-like hole (crevice) was periodically vacant was processed. A cylinder-like crevice is S= 10nm in the radius of r= 3.7nm, a depth (= height) of d= 34.1nm, and period.
[0020] Reflection property drawing in theta= 0 degree of incident angles of the optical member manufactured in the example 1 is shown in drawing 3 . Reflection property drawing in theta= 0 degree of incident angles of the optical member which formed magnesium fluoride (MgF2) monolayer (condition before vacating a periodic hole) on the fluorite substrate which is the conventional technology for the comparison is shown in drawing 4 . Although a reflection factor [in / in the optical member manufactured in the

example 1 / lambda= 157nm] is about 0%, it turns out that a reflection factor [in / in the conventional optical member / lambda= 157nm] is about 1.8%.

[0021] In this example, as a method of producing the optical member concerning this invention, although electron-beam-lithography method + dry etching was used for membranous production at production of a vacuum deposition method and a detailed pattern, it is not limited to this method. As a method of producing other, it is possible to membranous production to produce the optical member which the method using light which used energy particles, such as ion and a neutron, for processing of detailed patterns, such as the physical forming-membranes methods, such as a spatter and the ion plating method, and the chemical forming-membranes methods, such as a CVD method, such as a method and an X-ray, also requires for this invention.

[0022] Moreover, in this example, although the plane optical member was shown, it is not limited to this configuration and a convex lens, a concave lens, and a meniscus lens can also be produced.

[0023]

[Effect of the Invention] As mentioned above, as explained, since the heights which the optical member concerning this invention forms the optical thin film with which the crevice was periodically prepared on the substrate, or consist of an optical thin film material were formed periodically, the effect of polarization can acquire the small acid-resisting effect on the wavelength of arbitration. In the wavelength of 120nm - 180nm, the optical member which has the difficult acid-resisting effect can be especially offered by the Prior art.

[0024] If the residual reflection per whole surface is large when using it for the optical system used two or more pages is considered, the permeability (quantity of light) in the whole optical system will become small. Furthermore, in order to use it for highly precise optical system like a semiconductor aligner (stepper), residual reflection will cause deterioration of the image formation engine performance. Therefore, although the highly precise optical system in a 120nm - 200nm field is unrealizable in the optical member produced by the Prior art, implementation becomes possible by using the optical member of this invention.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the outline perspective diagram of the optical member of the 1st operation gestalt concerning ** and this invention.
[Drawing 2] It is the outline perspective diagram of the optical member of the 2nd operation gestalt concerning ** and this invention.
[Drawing 3] It is reflection property drawing in theta= 0 degree of incident angles of ** and the optical member of an example 1.
[Drawing 4] It is reflection property drawing in theta= 0 degree of incident angles of the optical member in which the monolayer which are ** and the conventional technology was formed.
[Drawing 5] It is the outline perspective diagram of ** and the conventional optical member.
[Explanation of agreement]
1 ... Layer containing heights
1a ... Heights
1' ... Layer which prepared the crevice
1a' ... Crevice
2 ... Substrate
3 ... Wedge-like thin film

[Translation done.]

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審査請求　未請求　請求項の数４　ＯＬ　（全５頁）

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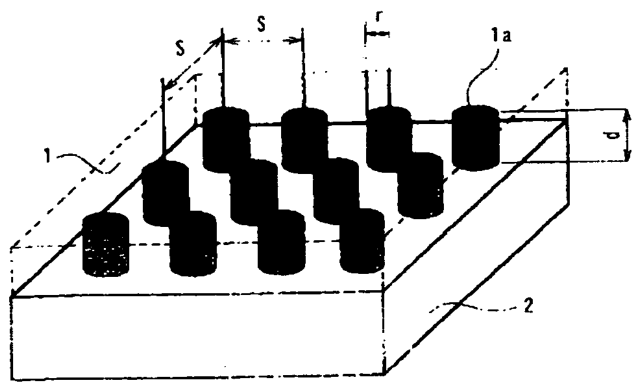
(54)【発明の名称】　光学部材

(57)【要約】
【課題】　使用波長120nm≦λ_0≦200nmで、入射光の偏光方向に依存せず、反射防止効果を奏する光学部材を提供する。
【解決手段】　凹部が周期的に設けられた１２０ｎｍ～２００ｎｍの波長領域用の光学薄膜材料からなる反射防止層を、或いは１２０ｎｍ～２００ｎｍ波長領域用の光学薄膜材料により凸部が周期的に形成されてなる反射防止層を基板上に有する光学部材。



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【特許請求の範囲】

【請求項1】凹部が周期的に設けられた１２０ｎｍ～２００ｎｍの波長領域用の光学薄膜材料からなる反射防止層を、或いは１２０ｎｍ～２００ｎｍ波長領域用の光学薄膜材料により凸部が周期的に形成されてなる反射防止層を基板上に有する光学部材。

【請求項2】前記周期長が使用波長の１／１０以下であることを特徴とする請求項１記載の光学部材。

【請求項3】前記１２０ｎｍ～２００ｎｍの波長領域用の光学薄膜材料が、MgF_2、CaF_2、ＬｉＦ、Na_3AlF_6、$Na_5Al_3F_{14}$、AlF_3およびこれらの混合物質又は化合物の群より選ばれた１つ以上の成分であることを特徴とする請求項１又２記載の光学部材。

【請求項4】前記反射防止層の実効的な屈折率が基板の屈折率に対して、

$n=(n_1)^{1/2}$

の関係を満たすこと或いは、前記層の光学的膜厚が使用波長に対して

$n\cdot d=\lambda_0/4$

の関係を満たすことを特徴とする請求項１～３記載の光学部材。但し、ｎは各凹部の空間（媒質）又は各凸部間の空間（媒質）を含む反射防止層の屈折率、n_1は基板の屈折率、ｄは前記反射防止層の膜厚、λ_0は使用波長

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明はＡｒＦレーザー、F_2レーザー等の１２０ｎｍ～２００ｎｍの波長領域の光に有効な反射防止膜に関するものである。

【０００２】

【従来の技術】光学系において、レンズ等の光学素子の表面反射による光量損失やフレア・ゴースト等を低減するために反射防止膜を形成する必要がある。このような反射防止膜の構成として、例えば、高屈折率層と低屈折率層を交互に積層する構成が挙げられる。また、１２０ｎｍ～２００ｎｍの波長領域で使用される光源としてArFエキシマレーザー（λ=193.4nm）やF_2レーザー（λ=157nm）等があるが、これらの光に対して有効な反射防止膜であるためには、低吸収・高耐レーザー性が要求される。しかし、使用波長$\lambda_0\leqq$２００ｎｍでは使用可能な高屈折率物質と低屈折率物質が少なくなる。特に、$\lambda_0\leqq$１８０ｎｍでは、吸収のない使用可能な高屈折率物質が、現在のところ存在しないため、有効な反射防止効果を奏する多層反射防止膜を得ることができない。

【０００３】一方、単層膜で所望の反射防止効果を得る方法として、従来から図５に示すように、光学基板１上に使用波長より小さな周期長で周期的にエッチングにより除去してくさび状の薄膜３を形成することによって、反射防止効果を有する光学部材は知られている。

【０００４】

【本発明が解決しようとする課題】しかし、図５に示すようなくさび状のパターンでは、入射する光の偏光方向によって反射防止効果を奏する偏光方向（図中のA方向）と反射防止の効果がない偏光方向（図中のB方向）が存在してしまう。即ち、入射光の電場の振動が、くさびの稜線方向に成分を持っている場合には、その成分は反射防止効果が得られない。　　　また、くさびの周期長は使用波長の１／１０以下でなければ反射防止の効果が小さいため、使用波長が短波長化するにしたがって、くさびの形状を形成することが困難になる。現実問題として、使用波長λが１μm以下では、くさびの周期長が0.1μm以下になるために、くさびの形状を精度よく形成（エッチングにより形成）することができない。

【０００５】そこで、本発明は、このような問題点に鑑みてなされてものであり、使用波長120nm≦λ_0≦200nmで、入射光の偏光方向に依存せず、反射防止効果を奏する光学部材を提供することを目的とする。

【０００６】

【課題を解決するために手段】本発明は第一に、「凹部が周期的に設けられた１２０ｎｍ～２００ｎｍの波長領域用の光学薄膜材料からなる反射防止層を、或いは１２０ｎｍ～２００ｎｍ波長領域用の光学薄膜材料により凸部が周期的に形成されてなる反射防止層を基板上に有する光学部材（請求項１）」を提供する。

【０００７】また、本発明は第二に、「前記周期長が使用波長の１／１０以下であることを特徴とする請求項１記載の光学部材（請求項２）」を提供する。また、本発明は第三に、「前記１２０ｎｍ～２００ｎｍの波長領域用の光学薄膜材料が、MgF_2、CaF_2、ＬｉＦ、Na_3AlF_6、$Na_5Al_3F_{14}$、AlF_3およびこれらの混合物質又は化合物の群より選ばれた１つ以上の成分であることを特徴とする請求項１又２記載の光学部材（請求項３）」を提供する。

【０００８】また、本発明は第四に、「前記反射防止層の実効的な屈折率が基板の屈折率に対して、

$n=(n_1)^{1/2}$

の関係を満たすこと或いは、前記層の光学的膜厚が使用波長に対して

$n\cdot d=\lambda_0/4$

の関係を満たすことを特徴とする請求項１～３記載の光学部材。但し、ｎは各凹部の空間（媒質）又は各凸部間の空間（媒質）を含む反射防止層の屈折率、n_1は基板の屈折率、ｄは前記反射防止層の膜厚、λ_0は使用波長（請求項４）」を提供する。

【０００９】

【発明の実施形態】以下に、本発明の実施形態としての光学部材について図面を参照しながら説明する。図１は、本発明にかかる第１実施形態の光学部材の概略斜視図である。図２は、本発明にかかる第２実施形態の光学部材の概略斜視図である。

【００１０】第１実施形態の光学部材は、基板１上に１

20nm～180nm波長領域用の光学薄膜材料からなる半径r、高さdの略円筒状の凸部1aが周期長Sで周期的に形成されている。第2実施形態の光学部材は、基板2上に半径r、高さdの略円筒状の凹部1a'が周期長Sで周期的に設けられた120nm～180nm波長領域用の光学薄膜1'が形成されている。

【0011】基板2として、120nm～180nmの波長領域の光を透過する、フッ化マグネシウム（MgF_2）、蛍石（CaF_2）が用いられる。120nm～180nmの波長領域で使用可能な光学薄膜として、基板と同じ材料又は基板の屈折率より小さい材料が好ましく、MgF_2、CaF_2、LiF、Na_3AlF_6、$Na_5Al_3F_{14}$、AlF_3およびこれらの混合物質又は化合物の群より選ばれた1つ以上の成分が挙げられる。

【0012】基板2上に凸部1aを形成し、その凸部1aを含む層1（以下、基板上に形成した凸部を含む層という）により、或いは基板上に凹部1a'を設けた層1'を形成することにより、実質的に所望の屈折率を有する光学薄膜（現在、存在しない）を基板上に形成した場合と同様な反射防止効果を得ることができる。基板上に周期的に形成されている円筒状の凸部1a又は凹部1a'の周期長Sは、使用波長をλ_0とすると、

$$S \leqq \lambda_0 / 10 \quad \cdots ①$$

であることが好ましい。

【0013】周期長を使用波長より十分小さくすると、光は凹凸を認識することが出来ないからである。また、凸部又は凹部の形状を円筒状にすることによって、入射光の偏光状態によらず、反射防止効果を有することができる。凸部又は凹部の形状として、円筒状の他に、円錐、半球、四角柱、四角錐、三角柱、三角錐等が挙げられ、これらによっても同様の効果を得ることができるが、製作しやすいという点では、円筒状が好ましい。

【0014】基板2上に形成した凸部1aを含む層1又は凹部1a'を設けた層1'の実効的な屈折率nは、単位（一周期）体積当たりに物質（薄膜）が存在する空間＊であり、

円筒（凸部）を構成する物質の屈折率：n_2

媒質（空気）の屈折率：n_0（=1）

とすると、基板上に形成した凸部を含む層の実効的な屈折率：

$$\begin{aligned} n &= (n_2V_1 + n_0V_2)/V \\ &= \{(n_2\pi r^2) + [n_0(S^2 - \pi r^2)]\}/S^2 \\ &= 1 + (n_2 - 1)\pi r^2/S^2 < n_2 \quad \cdots ② \end{aligned}$$

である。

【0015】これは、基板上に光学的膜厚d、屈折率$1+(n_2-1)\pi r^2/S^2$の薄膜を形成した光学部材と実質的に同じである。

（2）第2の実施形態にかかる光学部材の反射防止膜の屈折率について（図2）

単位（一周期）体積：$V = S^2 d$

円筒（凹部）の体積（媒質部）：$V_1 = \pi r^2 d$

物質（薄膜）の存在する体積：$V_2 = V - V_1 = (S^2 - \pi r^2)d$

であり、

物質（薄膜）の屈折率：n_2

媒質（空気）の屈折率：n_0（=1）

とすると、

凹部を設けた層の実効的な屈折率：

$$\begin{aligned} n &= (n_0V_1 + n_2V_2)/V \\ &= \{(n_0\pi r^2) + [n_2(S^2 - \pi r^2)]\}/S^2 \\ &= n_2 - (n_2 - 1)\pi r^2/S^2 < n_2 \quad \cdots ③ \end{aligned}$$

である。

【0016】これは、基板上に光学的膜厚d、屈折率$n_2-(n_2-1)\pi r^2/S^2$の薄膜を形成した光学部材と実質的に同じである。上記のように、基板上に形成した凸部1aを含む層1又は凹部1a'を設けた層1'の実効的な屈折率nは、円筒状の凸部1a又は凹部1a'の体積を変えることによって、空気の屈折率n_0（=1）から光学薄膜の屈折率n_2の範囲で、任意に変えることができ、凸部1aの光学薄膜材料又は凹部1a'を設け

射防止効果を得ることが可能になる。さらに、第１及び第２実施形態において、凸部及び凹部は周期的に設けられているが、凸部又は凹部の中心間の距離がλ_0／１０以下を満たせば、ランダムに設けてもよい。

【００１９】

【実施例】

〔実施例１〕まず、蛍石（CaF_2）基板上に膜厚ｄ＝３１．４nmのフッ化マグネシウム（MgF_2）を真空蒸着法により成膜した。次に、成膜したフッ化マグネシウム（MgF_2）上に、電子ビーム描画装置、ドライエッチング法を用いて、図２のような周期的に円筒状の穴（凹部）の空いた微細パターンの加工を行った。円筒状の凹部は、半径ｒ＝３．７nm、深さ（＝高さ）ｄ＝３４．１nm、周期Ｓ＝１０nmである。

【００２０】実施例１で製作した光学部材の入射角θ＝０°における反射特性図を図３に示す。　比較のために、従来技術である蛍石基板上にフッ化マグネシウム（MgF_2）単層膜（周期的な穴を空ける前の状態）を形成した光学部材の入射角θ＝０°における反射特性図を図４に示す。実施例１で製作された光学部材は、λ＝１５７nmにおける反射率は約０％であるが、従来の光学部材は、λ＝１５７nmにおける反射率は約１．８％であることがわかる。

【００２１】本実施例では、本発明にかかる光学部材を作製する方法として、膜の作製に真空蒸着法、微細パターンの作製に電子ビーム描画法＋ドライエッチングを用いたが、この方法に限定されるものではない。その他の作製法として、膜の作製にはスパッタ法、イオンプレーティング法等の物理的成膜法や、CVD法等の化学的成膜法など、微細パターンの加工にはイオン、中性子等のエネルギー粒子を使用した方法、X線等の光を利用した方法などでも本発明にかかる光学部材を作製することが可能である。

【００２２】また、本実施例では、平面の光学部材を示したが、この形状に限定されるものではなく、凸レンズ、凹レンズ、メニスカスレンズでも作製可能である。

【００２３】

【発明の効果】以上、説明したように、本発明にかかる光学部材は、基板上に、凹部が周期的に設けられた光学薄膜を形成し、或いは光学薄膜材料からなる凸部を周期的に形成したので、任意の波長で偏光の影響が小さい反射防止効果を得ることができる。　特に１２０nm～１８０nmの波長において、従来の技術では困難であった反射防止効果を有する光学部材を提供することができる。

【００２４】複数面使用した光学系に使用することを考えた場合には、一面あたりの残存反射が大きいと、光学系全体での透過率（光量）が小さくなってしまう。さらに、半導体露光装置（ステッパー）のように高精度な光学系に使用するためには、残存反射は結像性能の劣化を引き起こすことになる。したがって、１２０nm～２００nmの領域での高精度な光学系は、従来の技術で作製した光学部材では実現できないが、本発明の光学部材を使用することによって実現が可能になる。

【図面の簡単な説明】

【図１】は、本発明にかかる第１実施形態の光学部材の概略斜視図である。

【図２】は、本発明にかかる第２実施形態の光学部材の概略斜視図である。

【図３】は、実施例１の光学部材の入射角θ＝０°における反射特性図である。

【図４】は、従来技術である単層膜が形成された光学部材の入射角θ＝０°における反射特性図である。

【図５】は、従来の光学部材の概略斜視図である。

【符合の説明】

１・・・凸部を含む層

１ａ・・・凸部

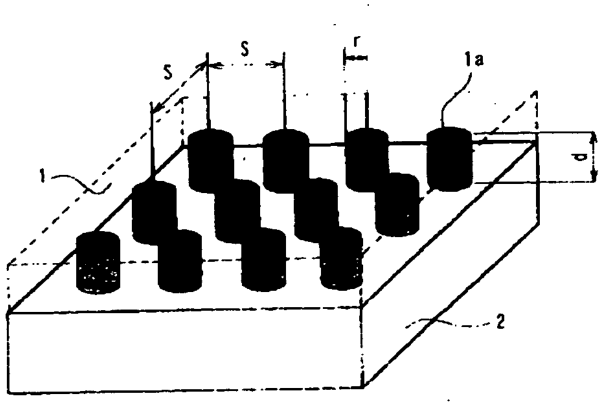
１’・・・凹部を設けた層

１ａ’・・・凹部

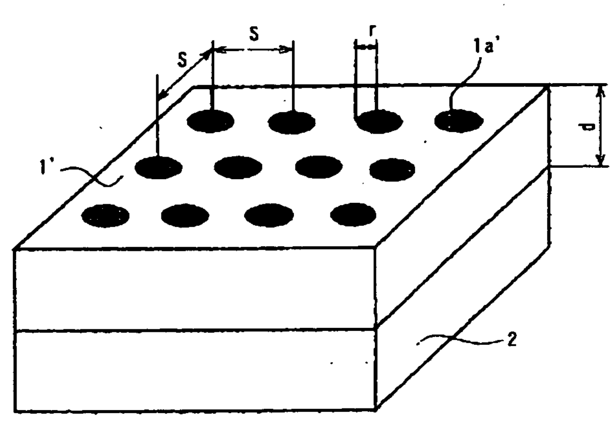
2.・・・基板

３・・・くさび状の薄膜

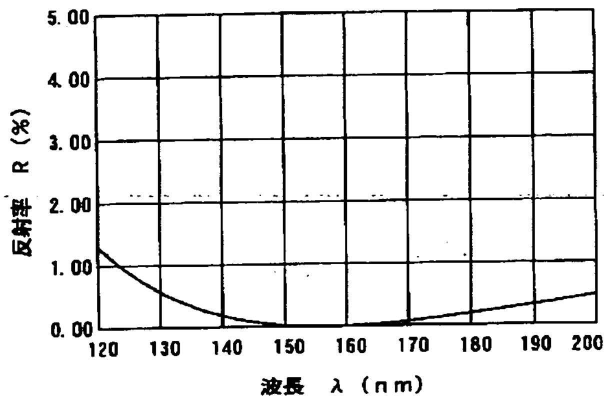
【図１】



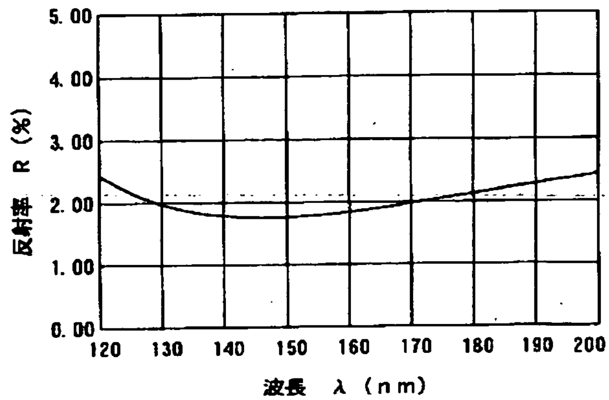
【図２】



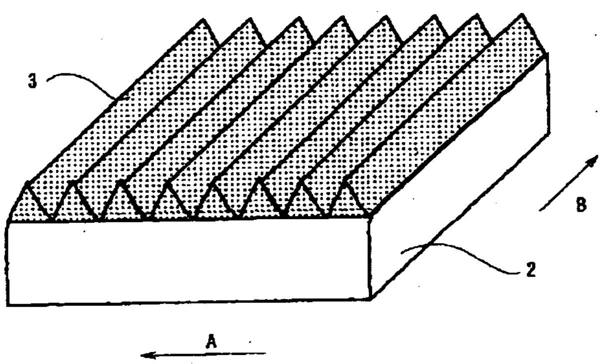
【図3】


5.00
4.00
3.00
2.00
1.00
0.00
反射率　R（%）
120
130
140
150
160
170
180
190
200
波長　λ（nm）

【図4】


5.00
4.00
3.00
2.00
1.00
0.00
反射率　R（%）
120
130
140
150
160
170
180
190
200
波長　λ（nm）

【図5】


3
2
B
A